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Grassland Ecosystem Services and Values at Risk

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Grassland Conservation Markets Symposium
Calgary, Alberta
November 19-20, 2019

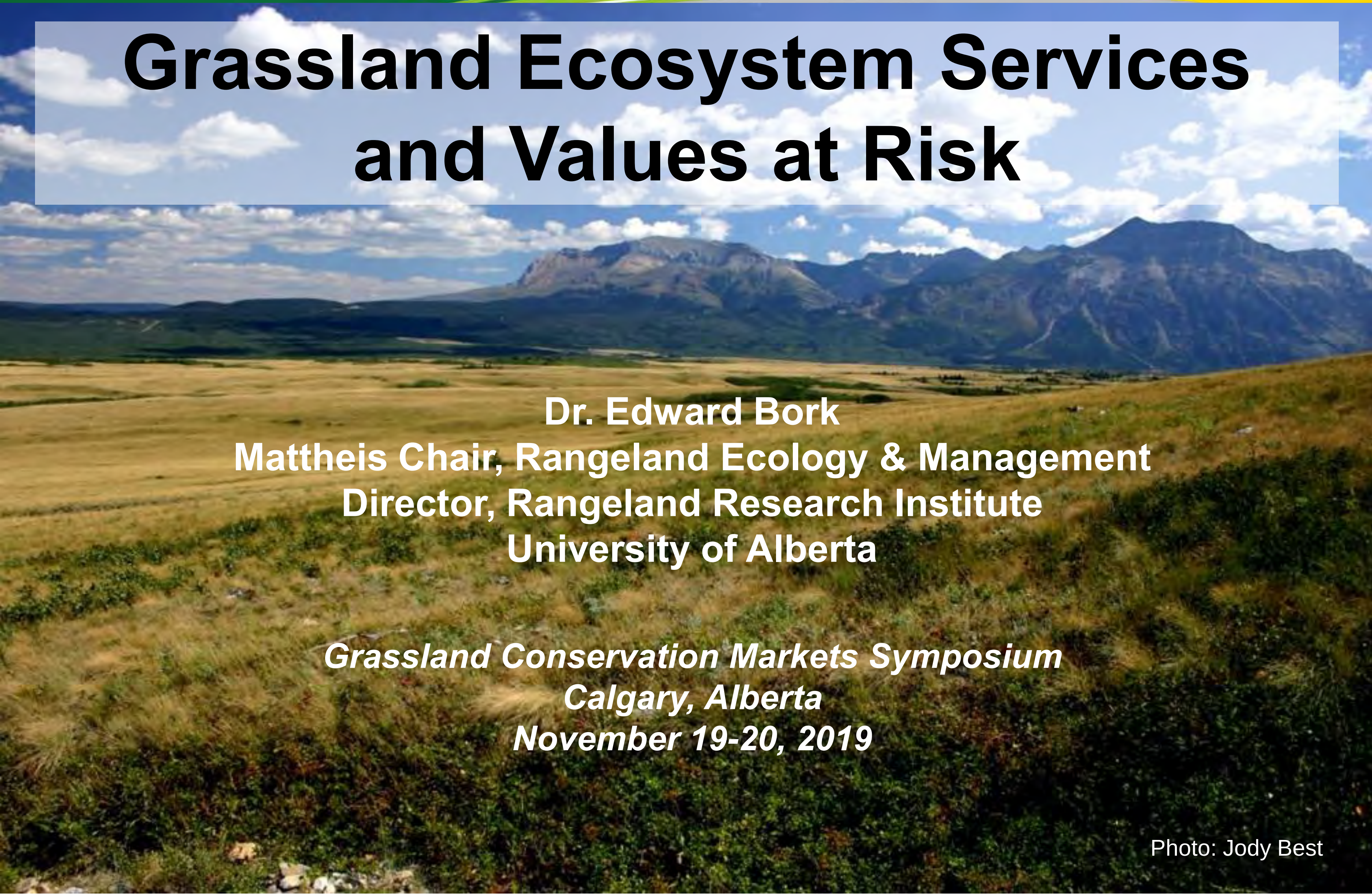


Photo: Jody Best

Presentation Roadmap

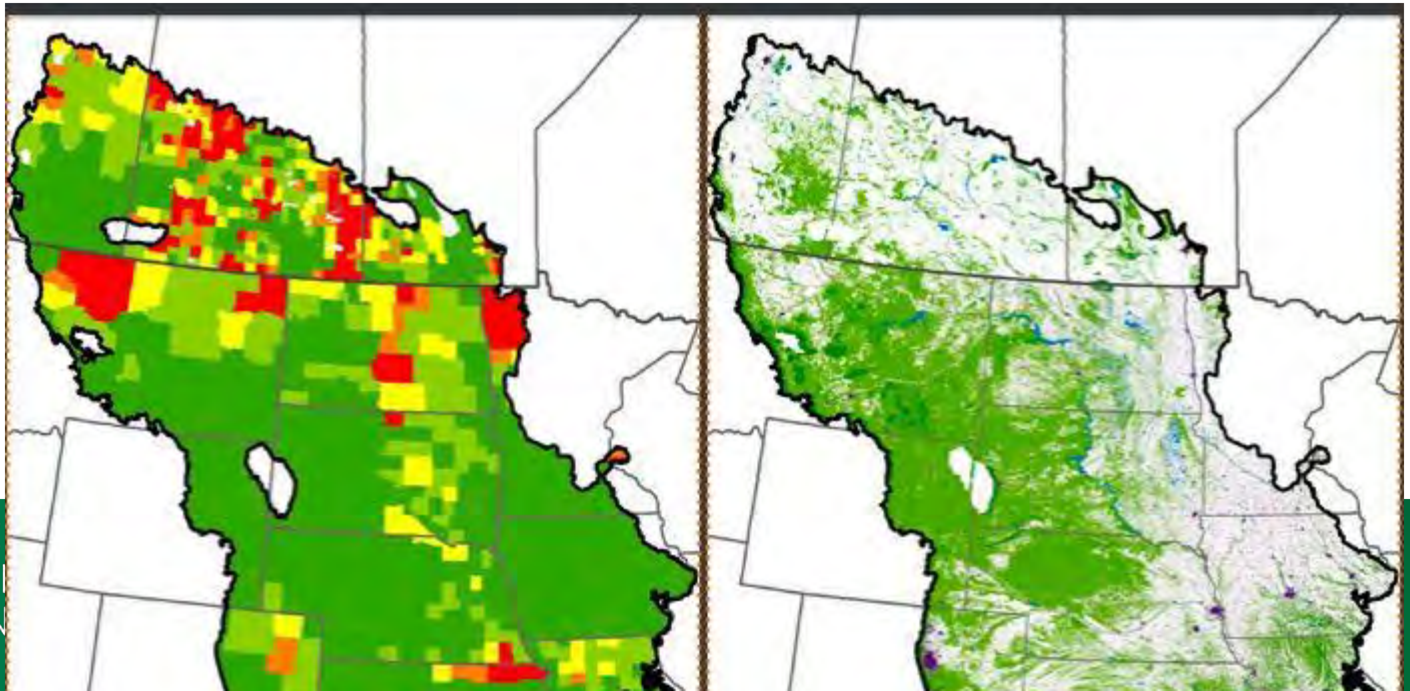
- Current status of grasslands in western Canada
- Importance of grassland EG & S and what is at risk
- Factors altering grassland EG & S
- Challenges measuring/validating EG & S
- Approaches & opportunities

Current Status of Canadian Grasslands

- While historically abundant globally, grasslands are declining world-wide (70-90% loss)
- Widely considered worlds most endangered terrestrial ecosystem
- Canadian (temperate) grasslands (W. Canada) have declined 76%

Right image:

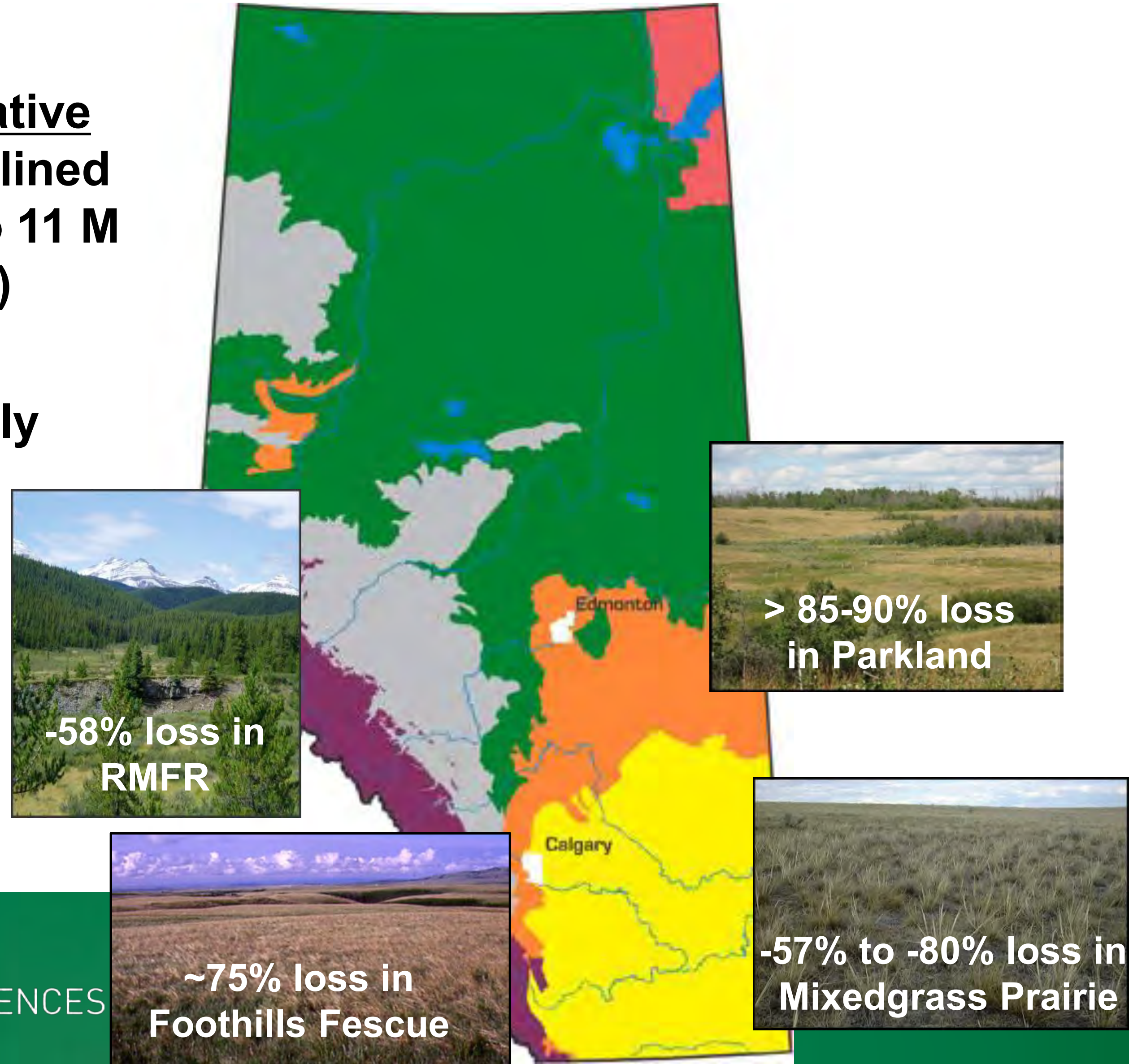
WWF Plowprint Report (2016)



Recent Estimates of Declines in the Prairie Provinces are Even Larger

- **Western Canada's <u>native grasslands</u> have declined 82%, from 60 M ha to 11 M ha (Bailey et al. 2010)**

- **Decreases vary widely among ecological subregions:**



So …. Why Care About Grasslands in Decline?

Photo: Lisa Raatz

What are Ecological Goods & Services?

"Physical, functional & socio-economic benefits to society from the existence of grasslands"

Water Purification & Flood Mitigation

Carbon/GHG Storage

Pollination

Forage/Livestock

Wildlife

Biodiversity/Habitat

Types of EG & S at Risk in Grasslands

- **Provisioning services:**
  - **Beef/forage *(ranchers/consumers)***
  - **Harvestable wildlife *(hunters)***
- **Supporting services *(everyone)*:**
  - **Biodiversity/Species at Risk**
  - **Nutrient cycling/retention**
  - **Water cycling and management**
  - **Pollination**
- **Regulating services *(everyone)*:**
  - **Climate modulation & GHG mitigation**
  - **Water storage & flood mitigation**
- **Cultural services *(everyone)*:**
  - **Ecotourism**

Beef Production

- Grasslands in Alberta (70% native) provide forage for 1.6M breeding beef cows, contributing >$3 B in primary sales to the economy (>$10 B in value added)

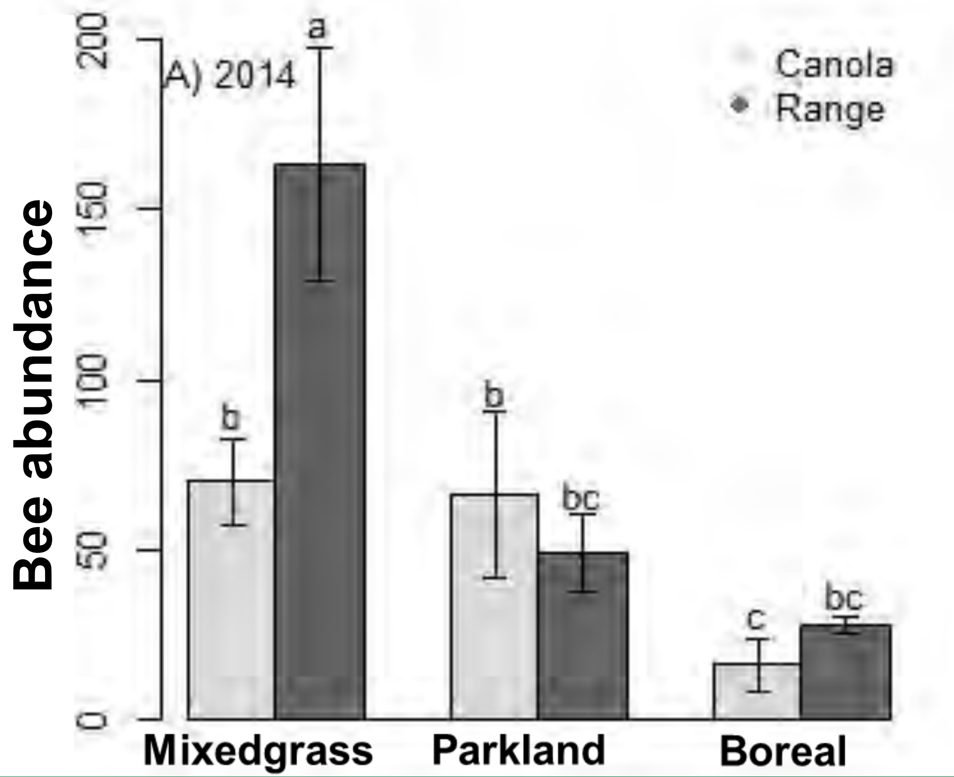
Grasslands Support High Biodiversity

(Compositional & Structural Complexity)

Diversity helps increase & stabilize provisioning services (e.g., forage) and C storage

Grasslands Provide Key Habitat for Pollinators (Cameron Carlyle)

- Pollinators support more than 80% of food crops globally
- Work to date in Alberta has found over 140 bee species
- Large areas of intact grassland support more bees, especially in the Mixedgrass Prairie



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Grasslands & Embedded Wetlands

- Healthy grasslands capture, store and slowly release valuable surface water, mitigating downstream flood risk

- Wetlands typically comprise 4% of prairie landscapes, but provide disproportionately high EG & S:
  - Wet meadows generate 2x greater forage yield than adjacent upland
  - Nearly 3x greater protein yield
  - Emergency forage in drought

Source: Asamoah et al. (2003)

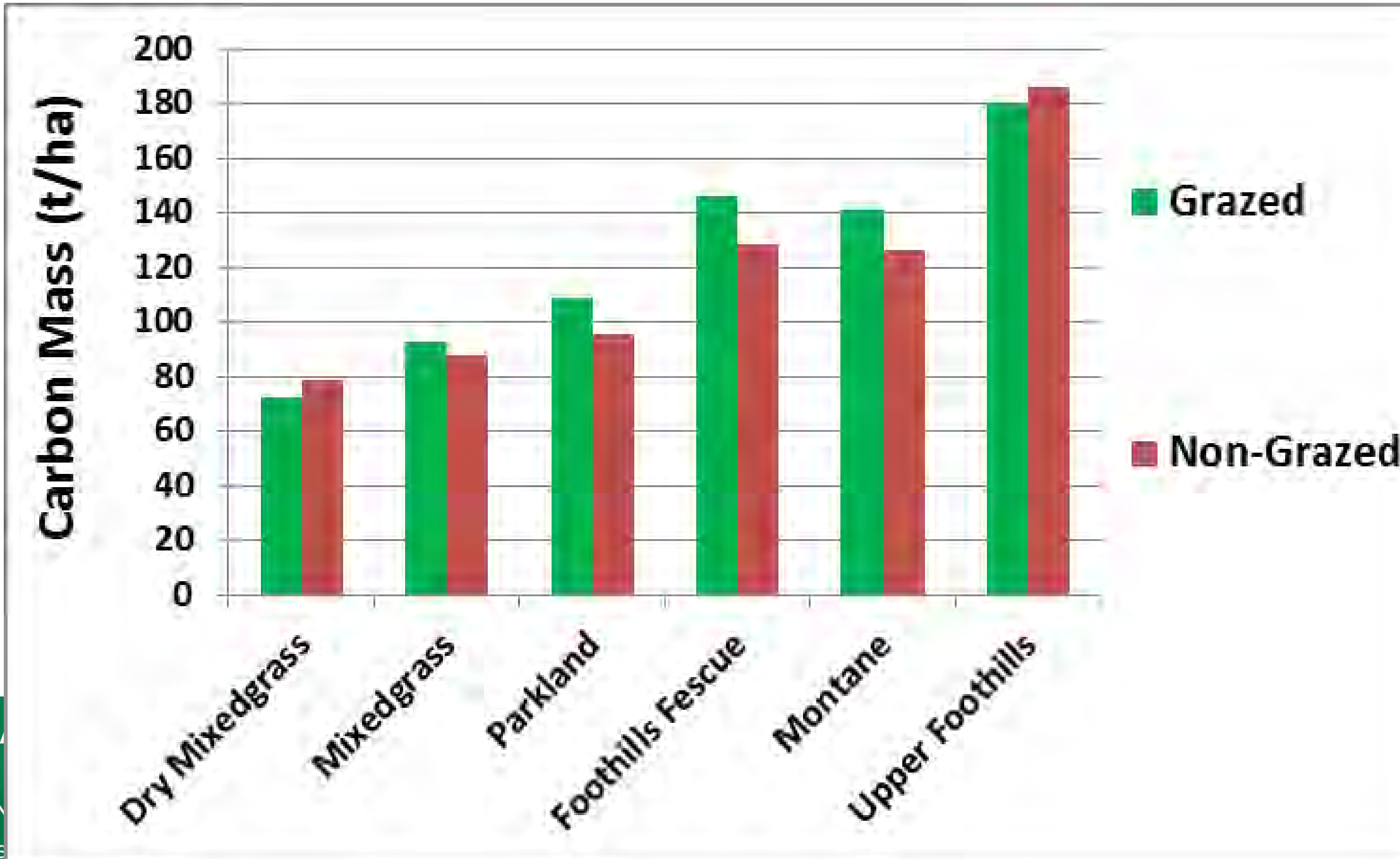
Rangelands & Carbon Storage

- Grasslands cover ~25% of terrestrial land globally and store 10 - 30% of the world's organic carbon (C)
- Temperate (cool-season) grasslands (~8% of earth's land surface) contain more than 300 Gt C:
  - 9 Gt in plants (3%)
  - 295 Gt in soils (97%)

Sources: Schuman et al. (2002); Lal (2002); IPCC (2000)

How Large Are Carbon Stocks in Alberta Grasslands?

Based on our benchmark assessment of C in >100 grasslands across AB, our conservative estimates are 70 to 180 t/ha – <u>values comparable to boreal forest & rain forest ecosystems!</u>

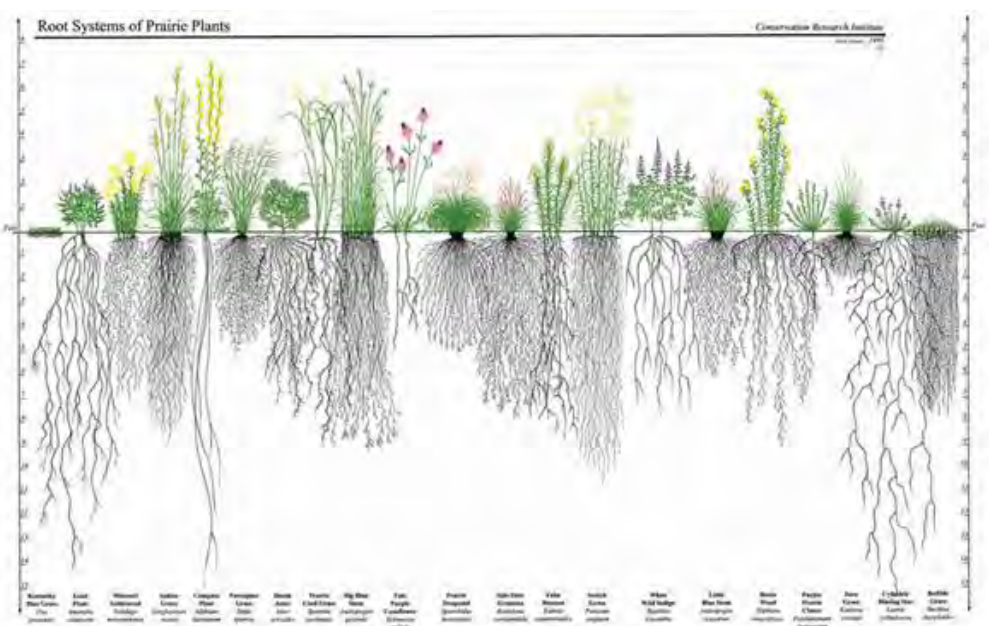


How ‘Protected’ is Grassland Carbon?

Abundant below-ground plant biomass (as much as 85%) leads to high soil organic matter (and C), where it is protected from disturbance (& therefore more stable)

‘Susceptible’ to short-term disturbance

‘Stable’ in short-term



Factors Impacting Grassland EG & S

1) **Land Use Conversion:**
   i) Urban-industrial (sub-urban sprawl, oil & gas, transportation)
   ii) Agricultural re-purposing (grassland conversion to cropland)

2) **Excessive/Altered Disturbance:**
   i) Overgrazing (becoming less common)
   ii) Recreational activities (increasing)
   iii) Severe fire & lack of wildfire

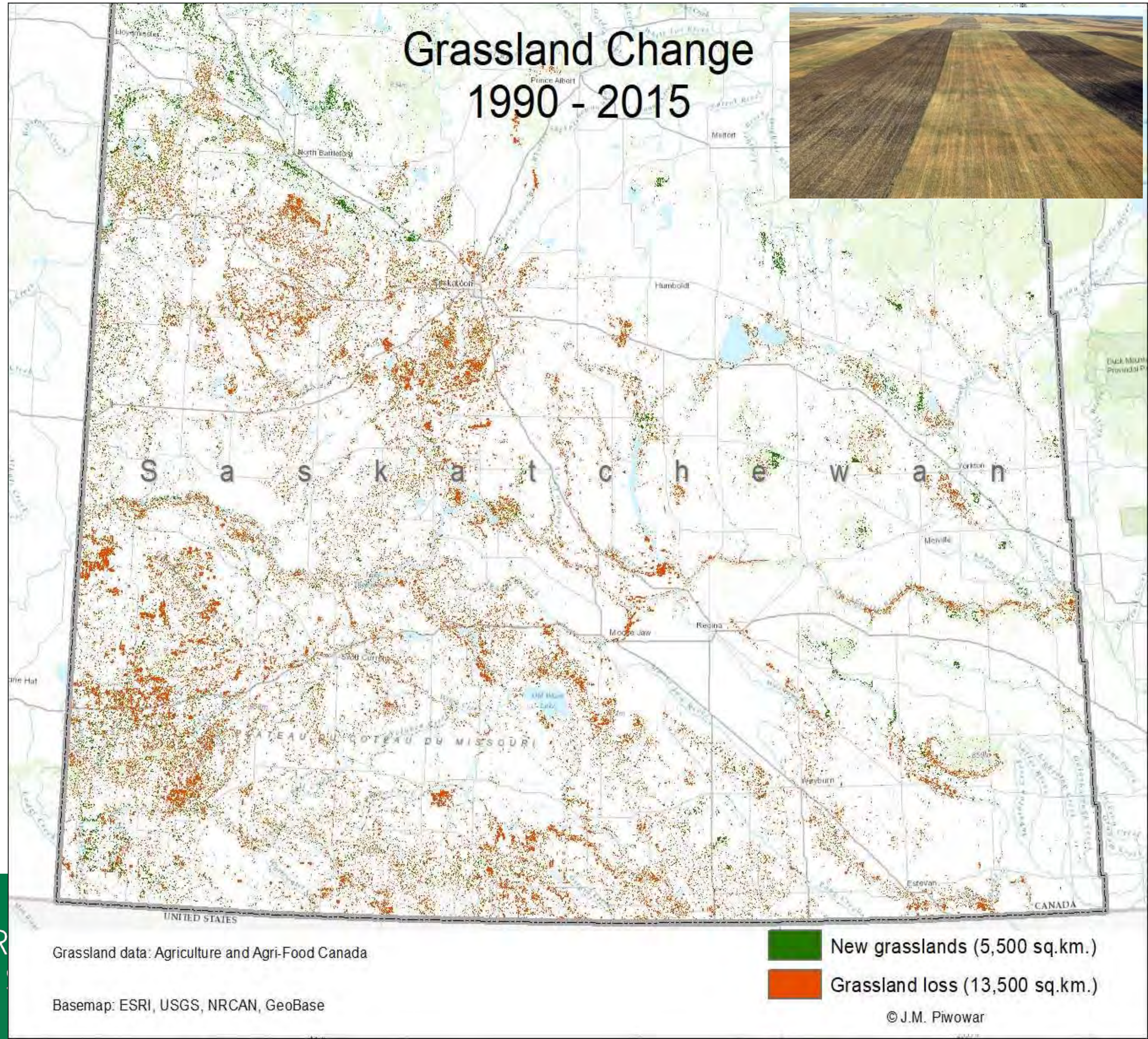
Urban-Industrial Sprawl Directly Leads to 'Permanent' Grassland Loss (+ EG & S Decline)

What was once a study site for doctoral research in Foothills Fescue Grassland (Dr. Steven Tannas) …

… has become ranchette housing (North of Cochrane)

Temperate Grassland Loss in Western Canada May Have Slowed, But Continues

- **1.3 M ha of grassland lost in SK** **(Map by Joe Piwowar)**
- **Expansion of 'new' grassland in north likely is replacement of forest with tame forage**
- **Grassland birds have declined 69% since 1970** **(WWF Living Planet Report)**



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How Does Cultivation Alter Carbon Storage in Grasslands?

<u>Cultivation</u> leads to the loss of 30-55% of grassland soil C worldwide:

1) Erosion

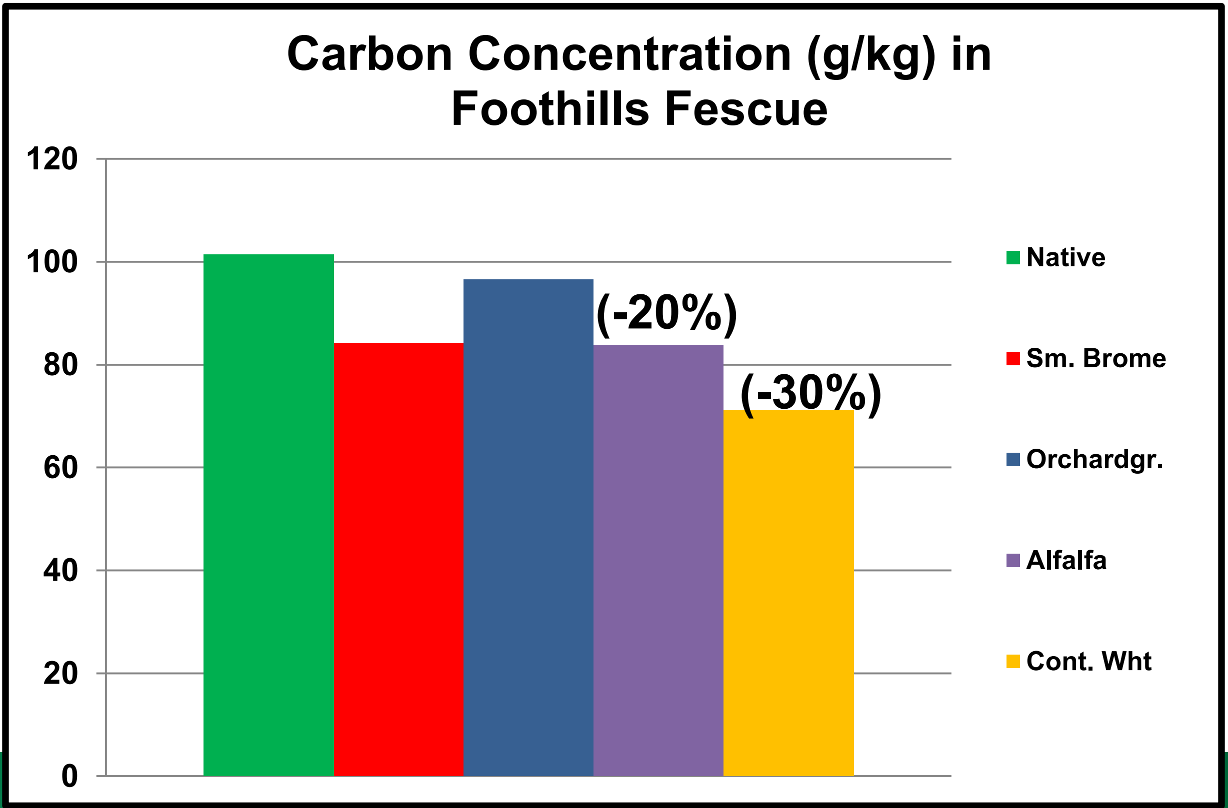
2) *'Furnace effect'*:

- **Warmer temps + Oxygenated soil = Increased microbial activity that hastens C release**

Source: Burke et al. (1995); Lal (2002)

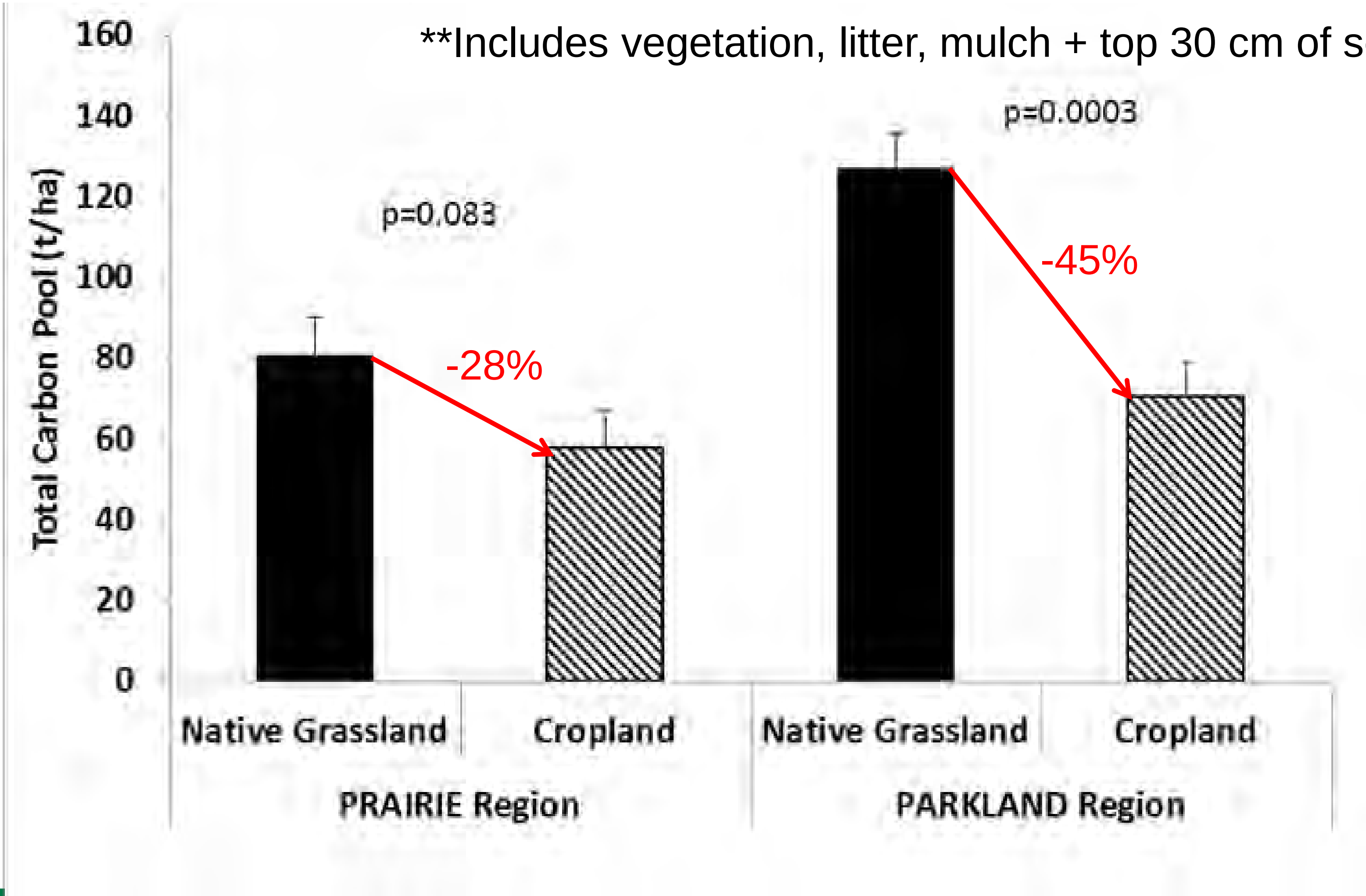
'Furnace Effect' Carbon Losses Under Alternative Ag Land Uses: Foothills Fescue

- **Soil C was 20-30% lower 5-6 yr after conversion of a fescue grassland with favorable moisture**
- **Lowest levels under annual cropping**
- **Intermediate levels under tame forage (brome, alfalfa)**



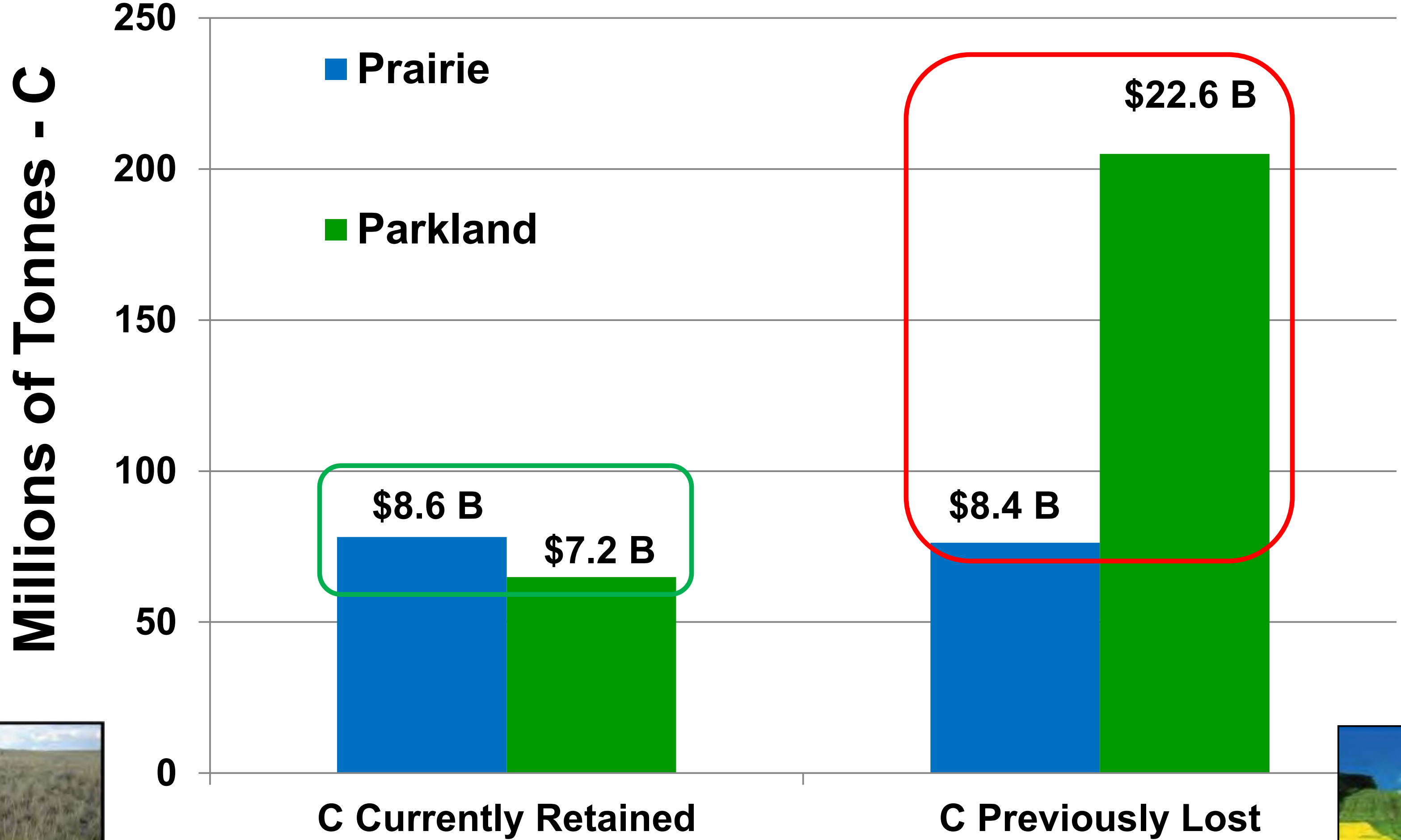
Source: Whalen et al. (2003)

Our Direct Comparison of Sites Across Alberta Also Has Shown Large Carbon Losses



What is the Value of C Retained/Lost in Alberta Grasslands?

Carbon stores derived using Benchmark field data + ABMI areas for land use change and a C-valuation of \$30/t-CO_2e (ERA)

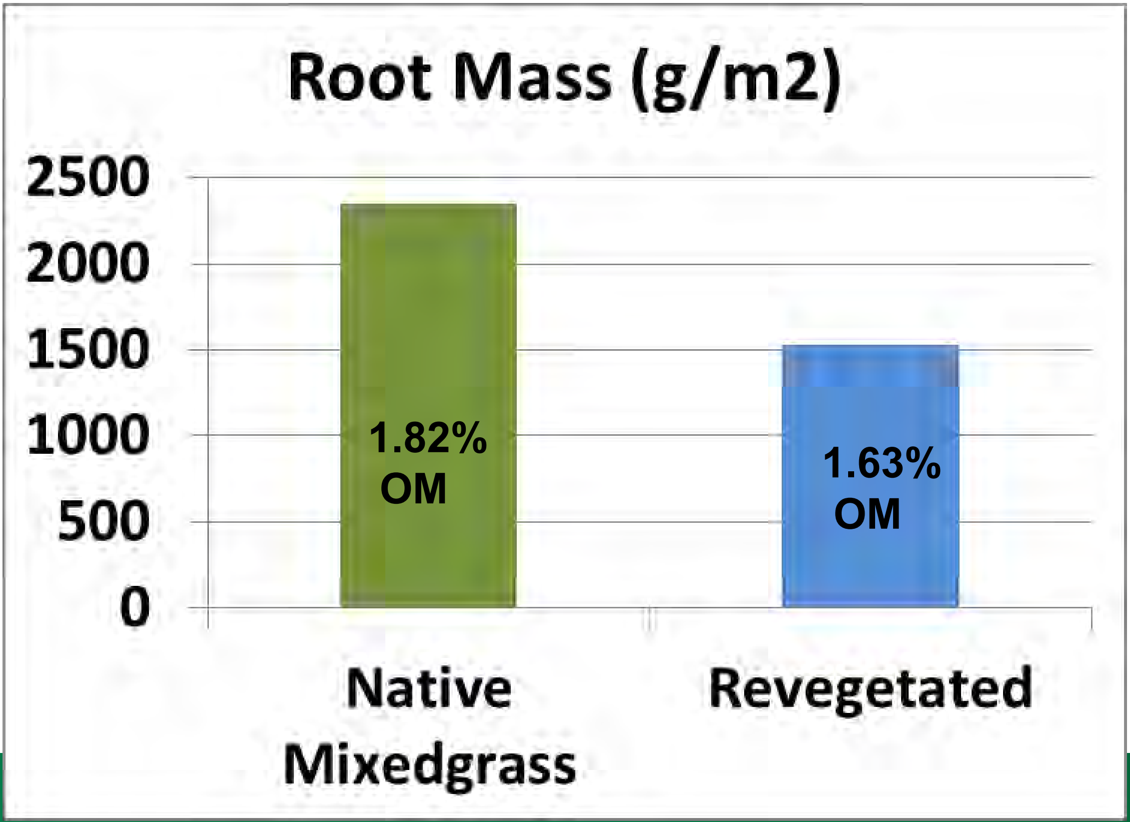


Comparison of Grassland VS Cropland

How Quickly Does Carbon Recover Once Lost from Cultivation?

Naturally re-vegetated Mixedgrass Prairie failed to recover in root mass & soil OM after 50 years

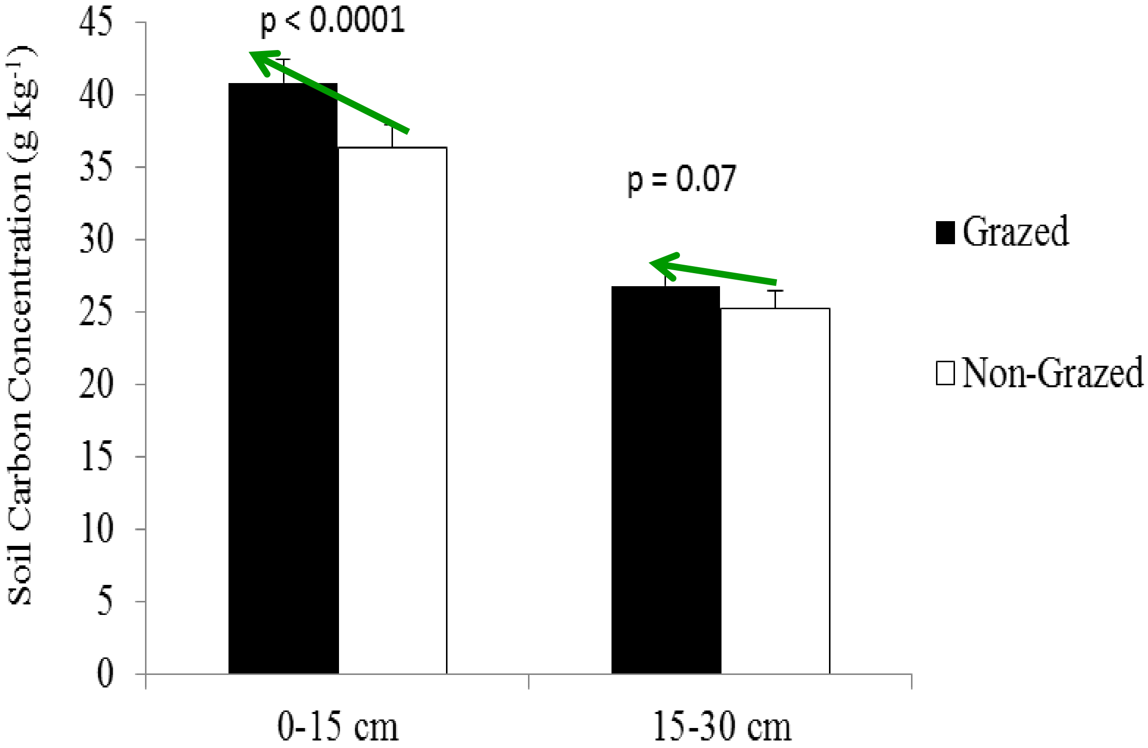
- ** Low resilience suggests long-term opportunity costs in C storage with land use conversion!



Source: Dormaar & Smoliak (1985)

Grazing Impacts on Soil Carbon Can Also be Positive

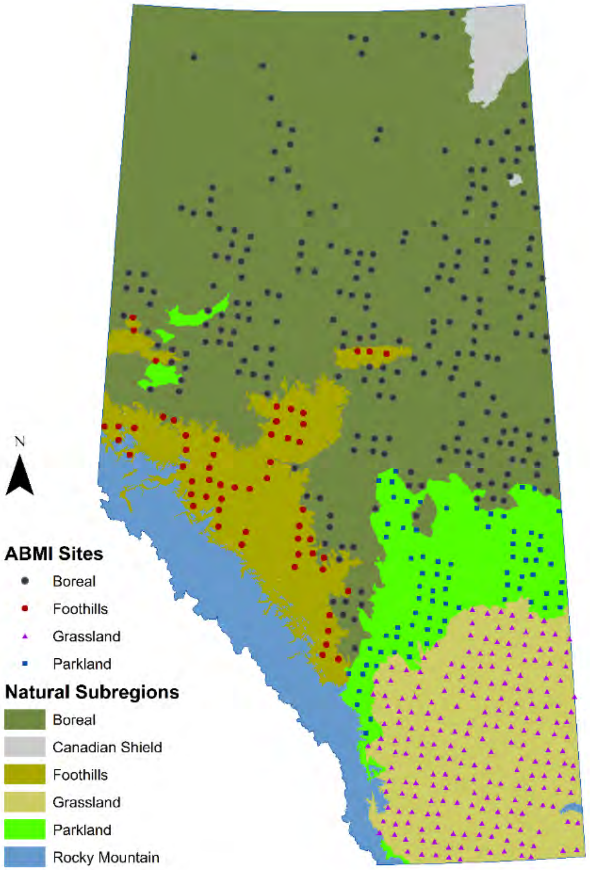
Long-term grazed grasslands had greater soil carbon concentration (by 12%), particularly in the soil surface (top 15 cm) of mesic grasslands



Source: Hewins et al. (2018)

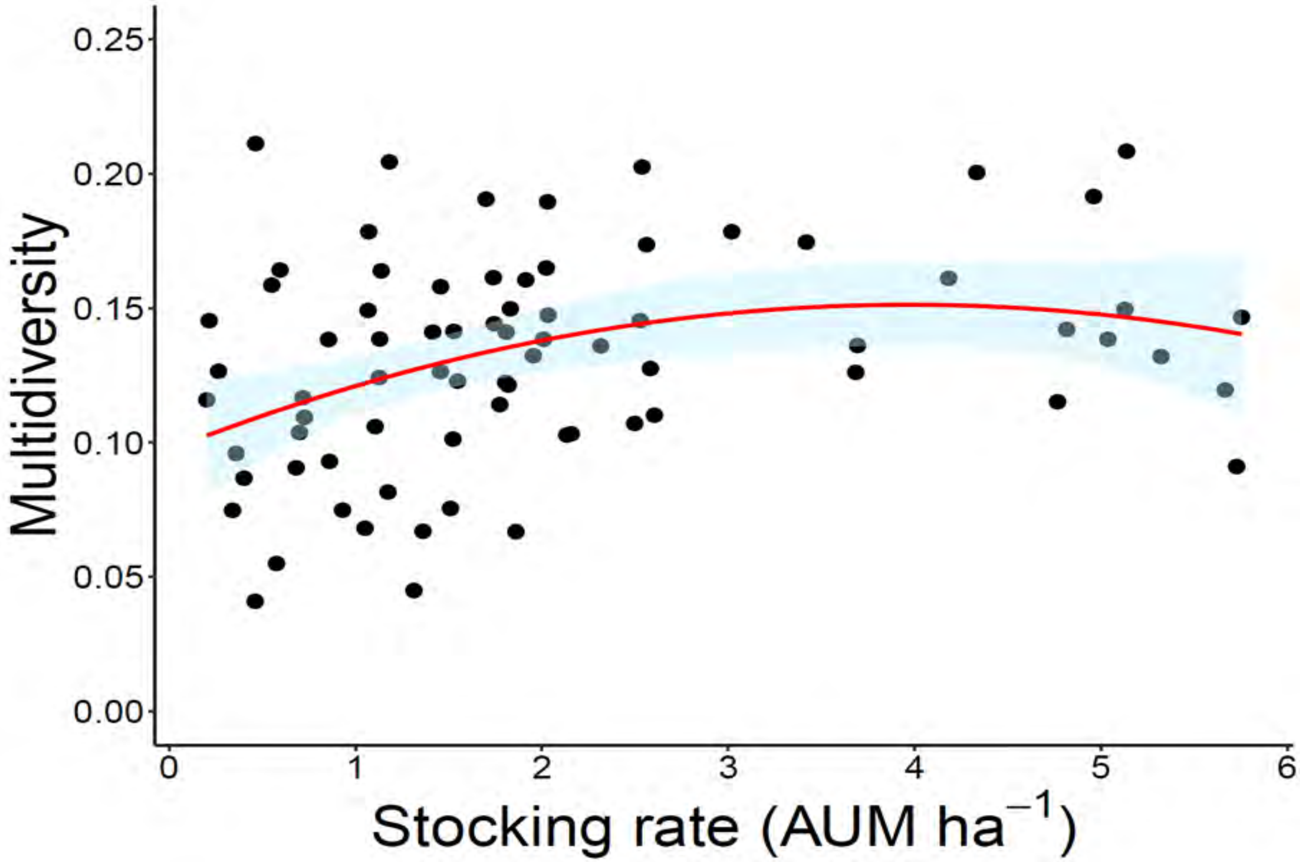
‘Beef & Biodiversity’ Study

Has enabled linkage of biodiversity data with land use activities (specifically cattle management practices) at ~200 sites across Alberta



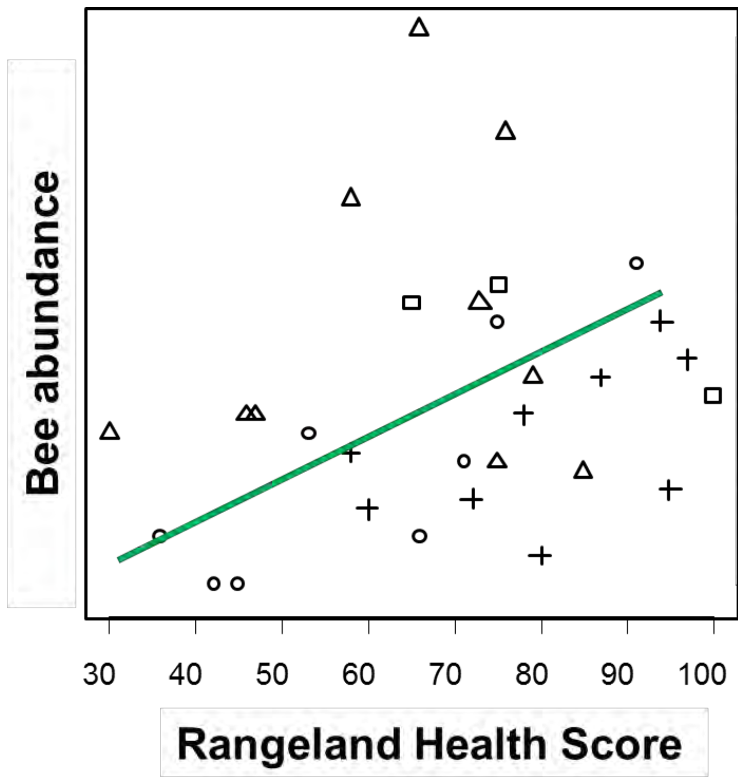
Grassland Ecosystems are Well-Adapted to Grazing

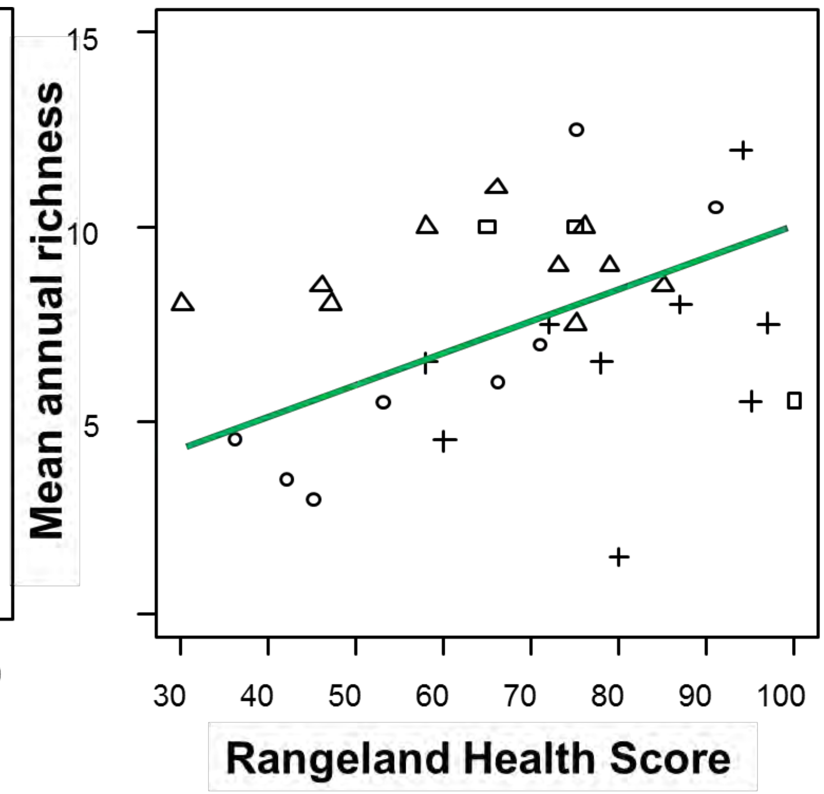
Grazing at moderate levels leads to greater multi-diversity, specifically of vegetation, moss, and bird species richness (Bao et al., in prep)



Heathy Grasslands Under Grazing Also Support Pollinators (Carlyle)

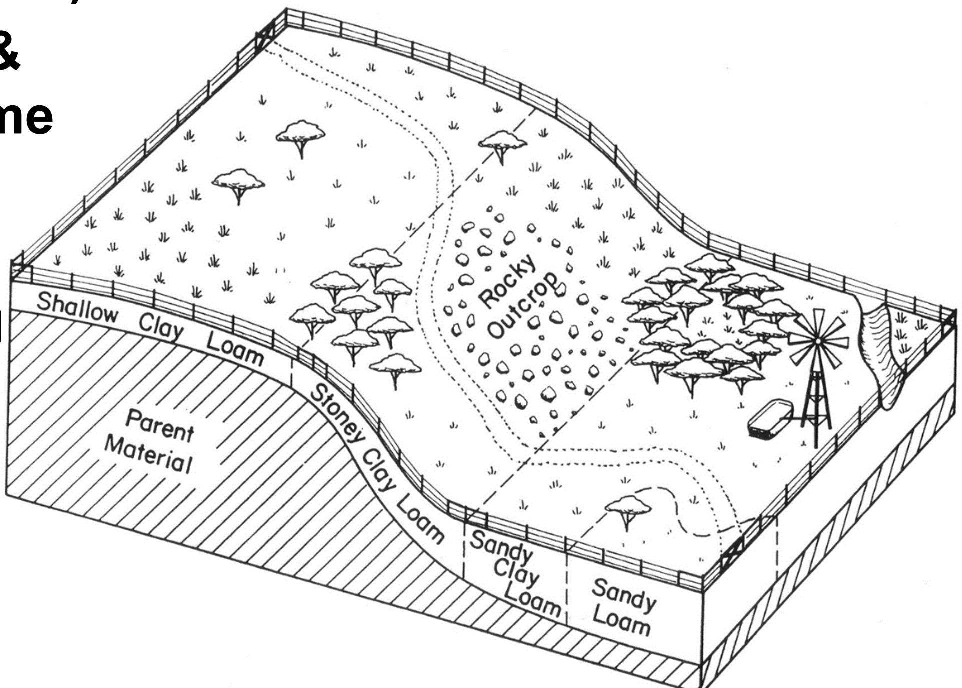
- Bee abundance and richness were positively related to grassland presence, range health, and forage quality





Challenges Measuring/Validating EG & S

- Grasslands are very heterogeneous, making synoptic quantification of EG & S within them impossible
- Further complicated by temporal variability (no 2 years are alike)
- Interpretation of management effects on EG & S are difficult (due to inconsistent SOP among ranchers)
- Innovations in remote sensing & drone technology may offer some solutions, but further testing is needed on problematic metrics
- Modelling to achieve up-scaling requires larger datasets (for calibration/validation)



Future Information Needs

- **More robust datasets, including an understanding of fundamental tradeoffs in EG & S in relation to different (competing) land uses**
- **Need to more fully understand the economic benefits (i.e., willingness to pay) of biophysical 'regulating and supporting' services (those for ranchers, AND those everyone benefits from)**

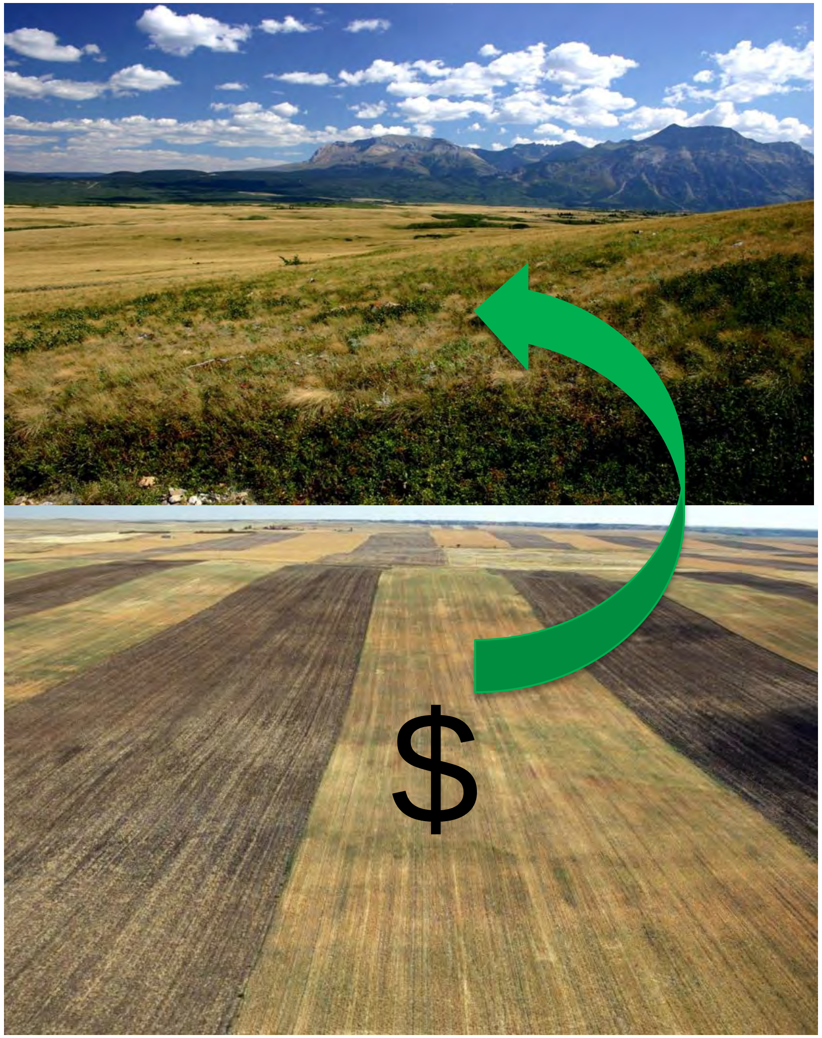
Possible Approaches & Opportunities

- **Suggest need to re-examine our thinking in how we assess EG & S:**
  - **Place greater value on what is there, rather than restoring what is lost (i.e., do not assume existing EG & S are likely to remain)**
  - **De-emphasize "additionality" in valuing EG & S**

- **Voluntary (non-regulated) market may be key in long-term protection of EG & S:**
  - **Grass-finished beef (<u>consumer</u> driven)**
  - **Alternative EG & S markets exist: "Fee access hunting" (need to overcome resistance to 'free services' in the past)**

Possible Approaches & Opportunities

- **Important to not lose sight of the 'big picture' when understanding historical land use change impacts on EG & S:**
    - **Perhaps radically re-think our funding model to transfer $ from land uses detracting from EG & S (urban-industrial/cropland) to those optimizing EG & S (grass managers) …**
        - ***EG & S reduction tax?***



Possible Approaches & Opportunities

- **Any approach will require extensive education/awareness of all involved (lay public/consumers, landowners, policy makers) on grassland EG & S**
  - **Landowners/ranchers have the opportunity to 're-imagine' their businesses (i.e., revenue streams)**
  - **Livestock industry should consider EG & S as a <u>new source of revenue</u>, not solely '*social license*' to operate**
  - **Future business models on private grasslands may be markedly different, with net income from EG & S comparable to, or even greater than, that from forage/beef**

Acknowledgements

- **Funders for supporting our ongoing research on EG & S**
- **Scientific Collaborators (Carlyle, Hewins, Chang, Cahill, Boyce, Bhrestha, & many others), & students (grad and undergrad)**
- **Cameron Carlyle (info on pollinators)**
- **Jody Best (photos)**

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